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A REPORT ON THE OCCURRENCE OF EXCESSIVE FOAM AT THE WHEELING, WEST VIRGINIA WATER PURIFICATION PLANT

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February 1954

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A Report on the Occurrence of Excessive Foam at the Wheeling,

West Virginia Water Purification Plant

On November 23, 1953, Mr. A. R. Todd, Superintendent of Water Treatment at Wheeling, West Virginia, noted a slight foam on the raw water basins and a slight taste in the water. Some rain, sufficient to cause flow in small streams that had been dry, occurred on November 20, 21, and 22. Virtually no rain had fallen previous to this time since July 1. The foam and taste increased and by December 1 three feet of foam existed on the raw water settling basins. Approximately two feet of foam extended from shore to shore (700 feet) on the Ohio River below Dam No. 12 at Wheeling.

This material had serious effects on the Wheeling water. Mr. Todd reported a strong fishy taste and odor in the water. Chlorine dioxide controlled the odor but the taste persisted. A black water condition developed in the distribution system and the water was straw colored. This was apparently due to loosening of scale and interference with normal iron and manganese removal. Water softeners could not be regenerated to produce zero hardness water and much foaming occurred in washing out the brine. There were complaints of vomiting possibly due to the fishy odor of the water. There were also complaints of tropical fish dying. By raising the pH of the water to 10.3 a clear water was produced.

Synthetic detergents were suspected to be the cause of the foaming, the taste and odor, and the difficulties in the water treatment processes. Analysis for detergents in the water by Mr. Todd gave the following results:

Date	Detergent Concentration in parts per million
Nov. 25	1
" 30	4
Dec. 1	4
" 2	12
" 3	4
" 5	3
" 6	1
" 7	trace

Treatment of the water consisted of breakpoint chlorination plus 5 lb/MG of lime and alum and up to 12 lb/MG of chlorine dioxide.

Mr. Todd collected samples of the foam in wash tubs and allowed the material to liquefy. Samples of this material were submitted to the Environmental Health Center and to authorities in Pennsylvania and West Virginia. Mr. Todd also collected several thousand gallons of the water in a tank during the period of difficulty. Part of this water was pumped through a carbon filter in accordance with a previous agreement to collect materials on carbon at times of unusual conditions.

Background on Detergents:

Before presenting the analytical data some general information on detergents is in order. These materials have been receiving increasing attention in the field of water treatment and sewage disposal. A good review of the problems encountered is given in Chemical and Engineering News, 31, 1072 (1953).

Production of synthetic detergents is expected to reach two billion pounds in the next year or two. Some 2500 different brands are currently being manufactured. However, relatively few molecular types of materials account for a high percentage of the total surfactant production.

The principal active ingredients of household detergents are known as anionics. Nonionics are also used domestically. The cationics (quaternary ammonia compounds) have special uses and are not presently important in water treatment. The anionics consist principally of alkyl aryl sulfonates and sodium alkyl sulfates. The structures of these materials are represented as follows:

Alkyl aryl sulfonate $C_{12}H_{25} - C_6H_4 - SO_3Na$

Sodium alkyl sulfate $CH_3(CH_2)_{10} \ CH_2 \ OSO_3Na$

Many variations of carbon chain length exist in these types of materials.

The active ingredients constitute approximately one third of the compounded detergent material. The remaining materials are largely phosphates, polyphosphates, builders and allied products. The phosphates may have adverse effects on the colloidal systems in water works and sewage disposal practice.

Analyses of foam samples and water:

The methylene blue method (Sewage Works Journal, 24, 658 (1952) and 25, 1, (1953)) was used in analyzing the samples of foam and water. This method consists of adding methylene blue to the acidified aqueous sample. The mixture is extracted with chloroform and the extract is compared by means of a spectrophotometer with standard samples. A sodium alkyl sulfate of molecular weight 288 was used as a standard. The method of analysis referred to above uses 350 as an average molecular weight. On the basis of the latter standard the foam collected at the

water plant contained 1170 parts per million (p.p.m.) of active detergent materials. The total detergent concentration in the foam would then be approximately 3500 p.p.m. assuming the active materials to be equivalent to one third of the total. A sample of the water collected in the tank was tested 30 days later and contained 1.4 p.p.m. of active detergent material.

The methylene blue test measures the total anionic type detergent and can be adapted for differentiating the alkyl sulfates and alkyl aryl sulfonates. Thiocyanates, nitrates and possibly certain proteinaceous materials interfere with the determination. Additional tests were made in an attempt to determine more specifically the type of material causing the foam incident at Wheeling. These tests included activated carbon adsorption studies and wet extraction methods.

Active Carbon Studies

The effect of activated carbon on these materials is of interest since this material may be effective in removing detergents from water. It was also of interest to determine whether the foam material could be adsorbed on and recovered from carbon as an aid in identification.

Procedure

A 250 ml. sample of the foam from the water plant and a similar sample of foam collected at Dam No. 12 were agitated with 10 grams of Nuchar-C 190 carbon for 30 minutes. The carbon was filtered and dried overnight. The filtrate did not foam when agitated, indicating adsorption of the foaming agent on the carbon. The carbon was extracted ten hours with chloroform followed by an 8 hour extraction with alcohol. The extracts were evaporated and weighed. The results are given below.

Recovery of Chloroform and Alcohol Extractable Materials from Foam Samples Treated with Carbon

Source of Sample	Chloroform Extract		Alcohol Extract	
	gram	ppm	gram	ppm
Wheeling Water Plant	.059	236	.224	896
Dam No. 12	.031	124	.094	376

The alcoholic extract of the carbon was prepared as a film on a salt plate and the infrared spectrum was obtained. Figure 1 is the spectrum of this extract and Figure 2 is the spectrum of a sample of pure alkyl aryl sulfonate (Santomerse-3). These curves are strikingly similar and there is no doubt that the Wheeling foam material was composed principally of the alkyl aryl sulfonate type compounds. Apparently the treatment of the foam with active carbon achieved a purification by eliminating interfering water-soluble materials and leaving the detergent material which was recovered in the alcohol.

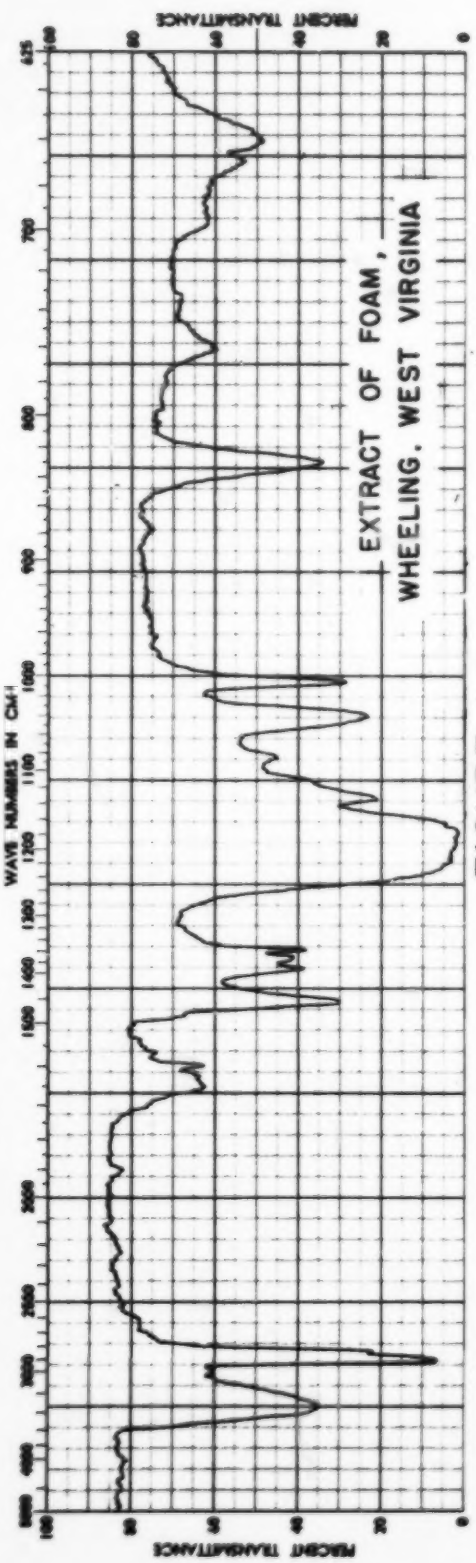

FIGURE 1

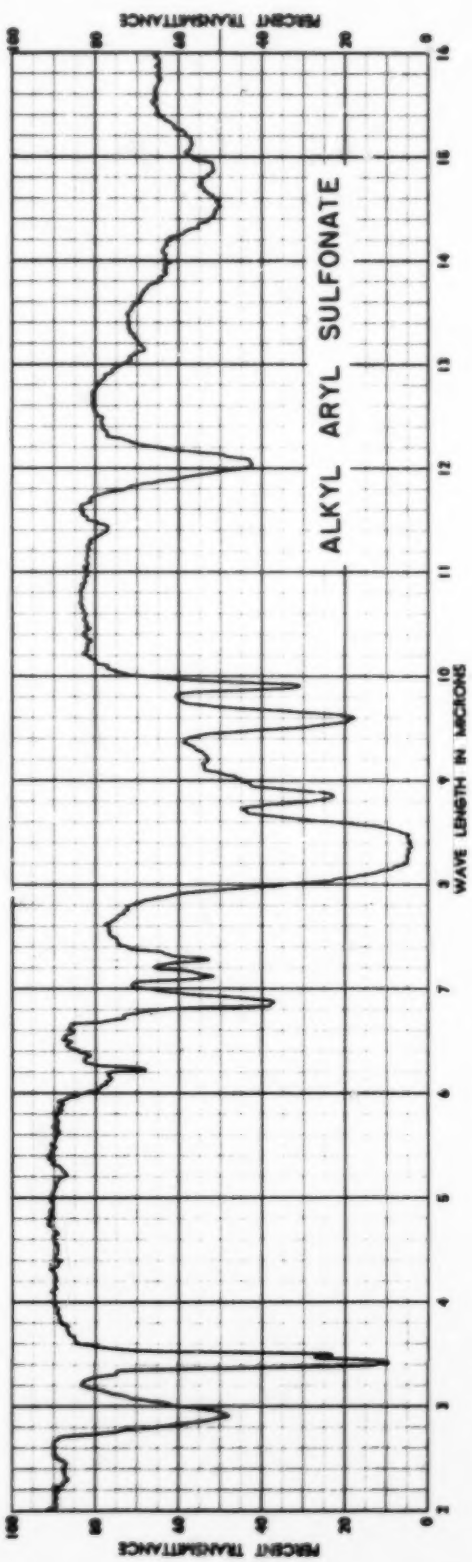

FIGURE 2

The alcoholic extracts were further assayed by the methylene blue method. A detergent equivalent of approximately 1000 p.p.m. was found in the water plant sample and a concentration of 260 p.p.m. was found in the sample from Dam No. 12. This experiment shows that concentrated solutions of these materials can be adsorbed and recovered from carbon. Insufficient work has been done to attempt quantitative interpretation from this type of study.

The water passed through carbon filters at Wheeling during the foam episode contained detergents in amounts of a few p.p.m. Preliminary examination of the carbon filter extracts did not reveal the presence of detergents. More work is necessary to determine the efficacy of the carbon filter on these types of materials.

Wet Extraction Method

The foam sample was extracted with chloroform. The aqueous material remaining was evaporated to dryness and taken up in absolute alcohol. A film was deposited from the alcoholic solution on a salt plate and the infrared spectrum was obtained. This spectrum showed many similarities to the spectrum of Santomerse-3. However, the wet extraction method apparently picked up other water soluble materials that interfered with the recovery of the detergent material. No attempt was made to further purify these substances. The chloroform extract showed, by infrared, some of the detergent characteristics. An alcoholic extract of the household detergent Tide was prepared and run on the infrared spectrophotometer. This spectrum had several similarities to the Wheeling foam spectrum but the resemblance was not as striking as that of the Santomerse-3. These tests do not imply that any specific proprietary product is responsible for the foam incident at Wheeling.

Discussion

The incident of the foam at Wheeling and the subsequent findings strongly point to the need for additional research on the effects of detergents on streams used as a source for water supplies. More suitable analytical methods need to be developed. Methods for treating waters containing these materials at the water plant have not been sufficiently studied. Great variability may exist in the persistence in water of detergent material and the allied compounding agents used in commercial formulations. Disruption of normal water treatment processes by such materials is cause for concern.

Respectfully submitted,

F. M. Middleton

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